

Approaches to financing green innovations in the formation of territorial logistic infrastructure

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Abstract The aim of the study is to substantiate and analyse the use of green innovation concepts in the formation of territorial logistics infrastructure. The measures for the application and financing of green innovations in the formation of logistics infrastructure, the environmental consequences of the development of logistics infrastructure, and the principles of the formation of logistics infrastructure are considered. A model for evaluating the effectiveness of green innovations, especially those related to environmental safety, is proposed. The rating of the energy infrastructure was considered, as a result of which the most "green" countries were identified, and the potential of the countries was considered for the implementation of green innovations in the formation of territorial logistics infrastructure. A SWOT analysis of the implementation of green innovations in the formation of territorial logistics infrastructure was compiled and proposed. There is a well-founded need to expand the range of green investments, which will ensure a reduction in greenhouse gas emissions by 65% in 2030 compared to 1990. In Ukraine, greenhouse gas emissions in 2021 were equal to 341.5 million tons, which is 7.5% more compared to 2020 but 62.5% less than the volumes of 1990. Proposed measures to reduce the negative impact of pollutants, aimed at preserving the infrastructure ecosystem, overall economic growth and strengthening the energy balance of the country.

1 Introduction

Innovative development of the economy is the only way to achieve technological progress in the country and strengthen the welfare of the population. In today's world, the need for innovative solutions is becoming more urgent and has a common general character. Green innovation is one of the conditions for rapid economic growth, especially if progressive humanity seeks to protect itself and future generations from natural disasters. The need for a gradual transition to a "green" type of economy and the creation and implementation of green innovations in everyday life cannot be ignored due to the strengthening of

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requirements for the level of ecological status of all sectors of the economy. "Green" innovations have particularly acutely affected the logistics infrastructure. After all, it is the rapid development of the logistics infrastructure and the increase in the number of shipments that cause an increase in CO2 emissions, noise, the consumption of natural resources, and waste.

Logistics infrastructure unites a certain group of enterprises in the complex activity of optimizing the movement of material, information-technological, and financial flows and contributes to the creation of a logistics strategy. The logistics infrastructure solves tasks related to the provision of: interests of logistics process participants; integrated use of transport, warehouse and forwarding capabilities; timely receipt of business information; mutually agreed actions of legal, financial, customs and insurance content.

Recently, questions have arisen that require an urgent solution, namely, regarding ecologically oriented logistics, which became widespread at the beginning of this century and considers logistics in the context of an effective toolkit for minimizing the harmful effects of production and economic activity on the environment. Ecologically oriented logistics is identified with the concept of "green" logistics and is not only environmentally safe, but also socially necessary and financially and economically justified.

A "green" economy benefits from the interrelationship between the economy and the natural environment, and in the future, wider segments of the population will be involved.

2 Literature review

The development of green innovations relies on a green growth strategy that takes into account the natural climate, the possibility of managing structural changes, and a favourable innovation environment.

A number of researchers have devoted themselves to studying the impact of the environment on logistics infrastructure. Rogers and Tibben-Lembke [1] single out the concept of "environmental logistics" and define it as "a set of activities related to the assessment and minimization of environmental impacts on the logistics infrastructure". The authors also emphasize that "green" logistics is implemented for environmental reasons and is considered through the prism of integrated management of logistics activities, which includes not only transport but also warehouse and management activities [1].

Yedlinskyi considers the category of "green" logistics as "an integrated grouping of all activities that are necessary to move a product through a supply chain to meet customer expectations at minimal costs due to climate change, pollution, noise, and vibration" [2]. The study of the issues of "green" logistics as part of the logistics infrastructure on the example of Polish enterprises is considered by Zowada (city of Katowice) [3], as well as Boichuk, who considered sustainable logistics as a basis for "green" logistics on the example of Polish cities [4]. The study of Rikhnak and Hubova [5] are devoted to consideration of "green" and "reverse" logistics in the infrastructure environment of Slovakia. It's worth paying attention to studies where the category of "ecological logistics" is defined and it is claimed that it is "a component of managing the flow of products from the supplier to the final consumer with minimal ecologically dangerous consequences."

The goal of environmental science is to "minimize the negative effects of production and economic activity on the environment" [6, 7]. Margita [8] and Bilonizhka [8] studied the level of development of "green" logistics in different countries and came to the conclusion that "there are certain gaps in the level of environmental hazards of logistics chains among developed countries and developing countries, which are associated with a lower number of international companies, a complex of problems of the level of development of logistics infrastructure, a low level of logistics services, a weak development of the potential of transit territories, and their relatively high cost" [8].

Countries with a high level of logistics service are Singapore, Hong Kong, and Finland. Now they can actively implement digital, ecological, and other technologies. Developing countries should pay more attention to the development of logistics infrastructure and the quality and level of logistics services. In the studies of Chortok [8] and Nechyporenko [8], attention is paid to the logistics infrastructure of green smart cities. Thus, according to the statements of these scientists, "the development of green smart cities is becoming widespread in various countries as an innovative model based on the digitalization of the development of regions, which will allow strengthening the level of well-being and quality of life of the population, improving environmental safety, and increasing energy efficiency. The process of rebuilding ordinary cities into green smart cities is carried out with the support of the European Union, since the EU Industrial Initiative has been implemented since 2011, which stimulates the introduction of the principles of energy efficiency and environmental safety at the regional level" [8].

In the study by Krykavskiy [9], attention is devoted to the definition of the concept of "logistics infrastructure", which is defined as "a system of means of spatio-temporal movement of formed logistics flows through the use of informational, financial-economic, and production-material components, and a set of counterparties of various forms of ownership by which the conditions for the implementation of these flows through the implementation of logistics services" [9]. Green innovation is an interconnected mechanism of innovation and environmental policy that accelerates the adoption of innovative decisions and the development of business models of an ecological nature. Green innovations cover a wide segment of innovations in various fields with the aim of strengthening the capabilities of products, services, and technologies and optimizing the use of resources while simultaneously reducing the negative impact of life on the environment [10]. The purpose of the study is to evaluate the theoretical and applied aspects of financing and application of green innovations in the formation of territorial logistics infrastructure, identify problematic aspects of the implementation of green innovations in logistics infrastructure, and conduct a SWOT analysis of the implementation of green innovations in the formation of territorial logistics infrastructure.

3 Methods

The implementation of the principles of the green economy requires consideration of the classification and priority directions for the implementation of green innovations. As part of the logistics infrastructure, it is worth highlighting road, railway, and air routes, their stations, tracks, terminals, ports, and containers, as well as types of vehicles [9]. It's worth noting that the development of green innovations in the formation of territorial logistics infrastructure should have a financial, economic, social, and environmental effect. When evaluating the effectiveness of green innovations, especially those related to environmental safety, the following model can be used:

$$\begin{aligned}
 NPV_{GI} = & \left[\frac{Re(1+r_b)^{T_a}}{(1+re)^{T_b}} + \frac{\sum (NPE_{tpp} + Atpp + EBtpp + EEBtpp)}{(1+re)^{T_b}} \right] + \\
 & \left[\frac{\sum (PNPE_{tb} + Ate + EEBte + (PNPE_{te} + EBte)(1+r_b)^{T_b - T_e})}{e(1+re)^{tb}} \right] - [\sum I_{tb}(1+r_b)^{T_b - tb} + \sum \frac{Itb}{(1+re)^{tb}}] \quad (1)
 \end{aligned}$$

where NPV_{GI} is the net present value of green innovations over the entire life cycle of the investment project; R_e - environmental risk, which is considered as the possibility of the occurrence of an extraordinary environmental event or danger, is defined as the sum of all possible damages caused to the environment; NPE_{tpp} , $PNPE_{te}$ – net economic profit, its distributed and undistributed parts from the implementation of the green innovation project during the payback period tpp , and operational period te , are achieved due to

increased production volumes, reduced operating costs, increased sales of green goods and services, increased level of environmental friendliness of products; EBt_{pp}, EBt_e - the amount of direct environmental benefits that can be received by the investor as a result of the implementation of a green innovation project, respectively, during the payback period t_{pp} , and operational period $-te$, manifested due to the reduction of tax payments, fees for emissions of pollutants, disposal of waste, reduction of fine payments for emissions of pollutants into the atmosphere; $EEBt_{pp}, EEBt_e$ - amounts of indirect ecological and economic benefits that may arise for third parties, respectively, during the payback period t_{pp} , and operational period $-te$; At_{pp}, Ate - amortization deductions in the process of implementing a green project, respectively, for the payback period t_{pp} , and operational period $-te$; I_{tb} - investment costs in the period of preparation for the implementation of the green project in year t ; I_{te} - investment costs during the implementation of the green project in year t ; r_b - rate of return on deposits; r_e - the ecological discount rate, which takes into account the risks of investing in this green project; t_b - the current year of implementation of green innovations; t_{pp} - the current year of receipt of cash flows during the payback period of the investment project; t_e - the current year of receipt of cash flows from the implementation of the green project; T_b - the time during which innovative investments will be made; T_{pp} - the payback period of a green innovation project; T_a - time during which there is a probability of occurrence of unpredictable environmental situations; T_e is the time of active operation and receiving a positive effect from the introduction of green innovations.

Indirect ecological and economic benefits are realized through an increase in the volume of agricultural production due to an increase in the yield and quality of crops, the production and sale of green products, an increase in the volume of income from the implementation of global ecosystem measures, which contributes to the reduction of soil erosion, the preservation of wetlands, the implementation of conservation measures ecosystem potential, implementation of measures to increase the investment attractiveness of lands in ecologically clean zones; obtaining additional income from the development of green tourism.

In the process of implementing green innovative projects, there is a high probability of both benefits and losses to third parties who are not directly related to the green project. Using the previous model and applying adjustment factors, we can calculate the net present value of green innovations, taking into account the positive and negative environmental results of third parties:

$$NPV_{GI} = \left[\frac{Re(1+r_b)^{T_a}}{(1+r_e)^{T_b}} + \sum \frac{(NPE_{tpp} + At_{pp} + EBt_{pp} + EEBt_{pp})}{(1+r_e)^{T_b}} \right] n_p \cdot n_n + \left[\sum \frac{(PNPEt_b + Ate + EEBt_e + (PNPEt_e + EBt_e)(1+r_b)^{T_b - T_e})}{e(1+r_e)^{tb}} \right] n_p \cdot n_n - \left[\sum I_{tb}(1+r_b)^{T_b - tb} + \sum \frac{I_{te}}{(1+r_e)^{te}} \right] \quad (2)$$

where $n_p \cdot n_n$ are correction coefficients of positive and negative environmental results of third parties [11].

4 Results

In Ukraine, there is a tendency to increase the amount of capital investments for the protection of the natural environment, which contributes to the strengthening of the level of environmentalization of the economy, which includes expenses for the protection of atmospheric air and climate change problems, wastewater treatment, waste management, and their utilization, as well as rehabilitation of soil, underground, and surface water [12-15], which can be seen in Figure 1.

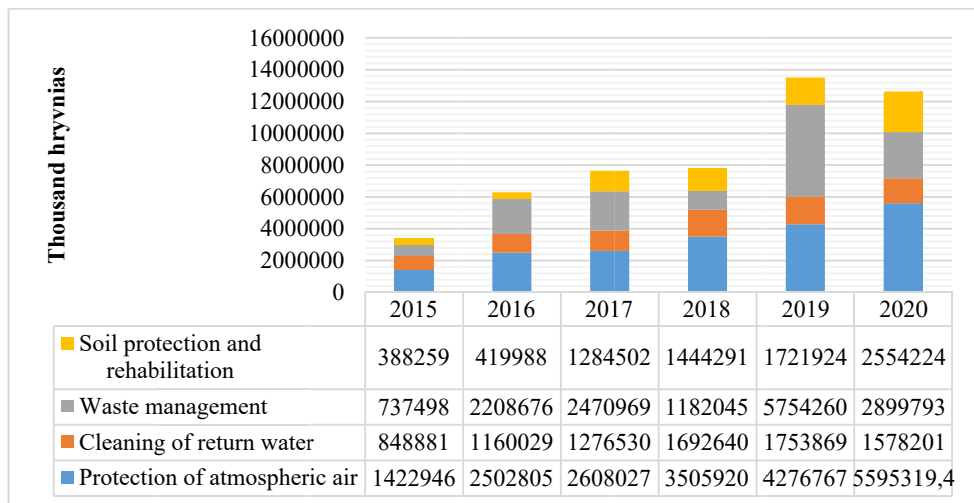


Fig. 1. Capital investments for environmental protection in Ukraine (thousand UAH) [13].

The level of customs service, the level of infrastructure development, the volume and level of international shipments, the level of competence of logistics specialists, the level of cargo tracking, and the timeliness of delivery are important for evaluating the integral indicator. Thus, the financial and economic effect of the development of territorial logistics infrastructure is achieved through the use of combined transportation, cost-effective routes, optimal use of warehouse areas, the use of adequate pricing for logistics services, which will entail higher added value and increased profitability. A positive financial and economic effect is ensured by creating a favourable business environment, reducing tax pressure, and effective fiscal and budgetary policy [16-18]. The ecological effect of the development of the territorial logistics infrastructure is achieved through the use of renewable energy sources, the wider use of energy-saving technologies, the use of "green" packaging, the minimization of emissions of harmful substances into the atmosphere, and the spread of the use of environmentally friendly vehicles.

The social effect of the development of territorial infrastructure is achieved through increasing the social responsibility of business representatives, improving "green" management (environmental quality management, training employees in environmental management knowledge, and promoting initiatives on environmental measures, adjusting environmental management strategies). Undoubtedly, the classification proposed by us can be supplemented as a result of further research and manifestations of green innovative activity. Green innovations can be implemented in different directions [19-20]. But the following can be considered priorities (Figure 2).

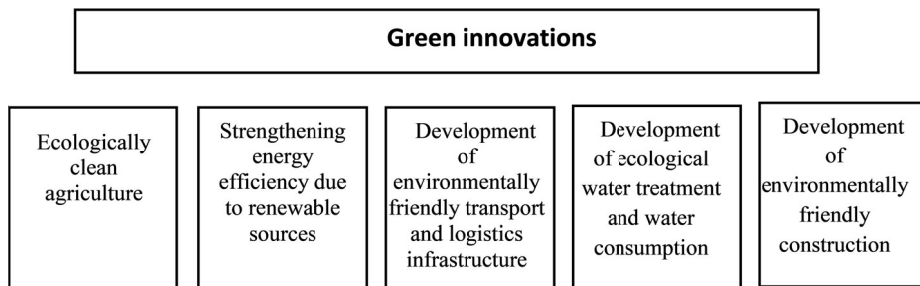


Fig. 2. Directions for the implementation of green innovations.

The main direction of green innovation is the development of logistics infrastructure. It is clear that territorial logistics is related to urban planning and city architecture, transport networks and communications. The use of the principles of green innovations in the formation of the territorial logistics infrastructure primarily depends on the local government, which by its actions initiates the formation of qualitatively new conceptual foundations of the city's development, and the optimization of economic and financial, ecological and social factors [20-22].

Research shows that up to 10% of emissions of greenhouse gases and hazardous substances fall on objects of the logistics infrastructure, and the source of danger for 50% is transport, 90% of which is freight. The development of logistics infrastructure has a negative impact on the environment to some extent. Therefore, it is worth highlighting the functional areas of logistics and the environmental consequences of its implementation (Table 1).

Table 1. Environmental consequences of logistics infrastructure development.

Type of logistics services	Environmental consequences
Supply	Increasing the volume of packaging, containers, and solid waste; contact of employees with environmentally hazardous materials (gas, fuel, chemicals, pesticides); soil load
Information technology operations	Radiation when using information and technological means, increasing the volume of waste at the stages of sorting and certification
Marketing	Leakage, spillage, evaporation due to poor packaging
Production service	Increasing the size of land plots for the placement of logistics terminals and storage of production waste; increase in noise and vibration
Transportation	Emissions of harmful substances during the operation of vehicles, noise and vibration load

The use of green innovations in the formation of territorial logistics infrastructure requires significant innovative resources with the support of funds from the State and local budgets and business. The source of attracting green innovations is the provision of grants, technical and technological support, credit resources and other financial instruments.

To assess the level of logistics, the "Integral indicator of logistics efficiency, Logistics Performance Index (LPI), is calculated, which takes into account the following components: the level of Customs ; level of infrastructure development; the level of international transit shipments; Logistics quality and competence; the level Tracking and tracing; Timelines" [8].

Our own scientific research on the implementation and application of green innovations makes it possible to form our own vision on the types of green innovations in the formation of territorial logistics infrastructure, which are presented in Figure 3.

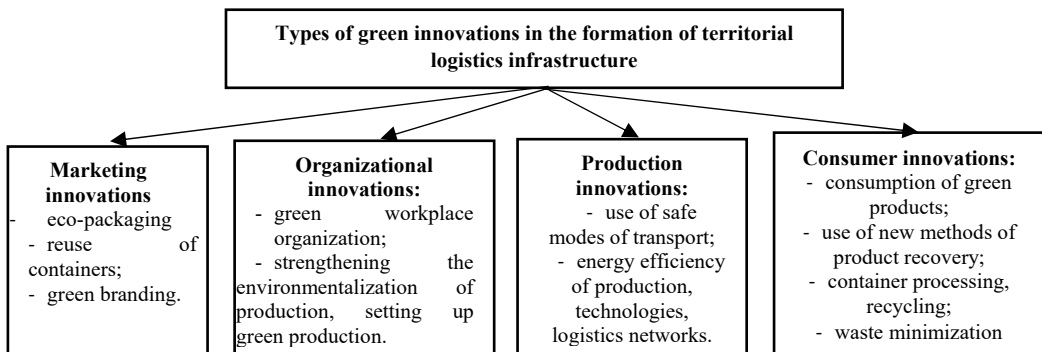


Fig. 3. Types of green innovations in the formation of territorial logistics infrastructure.

The implementation, financing and application of green innovations in the formation of territorial logistics infrastructure is carried out according to certain principles, which should be divided into the principle of system approach, rational placement, logistics coordination, stability and adaptability (Table 2).

Table 2. Principles of territorial logistics infrastructure formation.

Principle	Essence
System approach	Approaching the territory as a system, obtaining the maximum effect through the optimization of the entire logistics flow
Rational placement of production	Optimizing the combination of the sanitary zone of the city and the source of qualified labor
Logistics coordination	Ensuring consistency in time of all logistics links through the development of directions for managing material and technical flows, mutual consistency of logistics standards and technical conditions of logistics, forecasting supplies and means of production with minimal negative environmental impact.
Stability and adaptability	Ensuring the minimum impact of developed logistics infrastructure, social and ethical impact on territorial sustainable development

The development of logistics infrastructure requires the creation of a sustainable environmental image, which will contribute to the implementation of "green" logistics [23-26]. The use of green innovations in the formation of the territorial logistics infrastructure singles out the key advantages that companies receive and carry exclusively image content, while the issues of increasing the efficiency of business processes, reducing costs and increasing the level of wages become secondary [27-29]. Thus, the philosophical idea of using green innovations in the logistics infrastructure is clearly followed, the corporate responsibility of business structures increases, and the greening of business based on the use of logistics concepts is clearly observed [30-31]. It's important to note that the implementation of social responsibility of business can only be carried out by powerful companies with sufficient financial capabilities. Factors that actively contribute to the development of "green" logistics should be considered according to the degree of their influence (Figure 4).

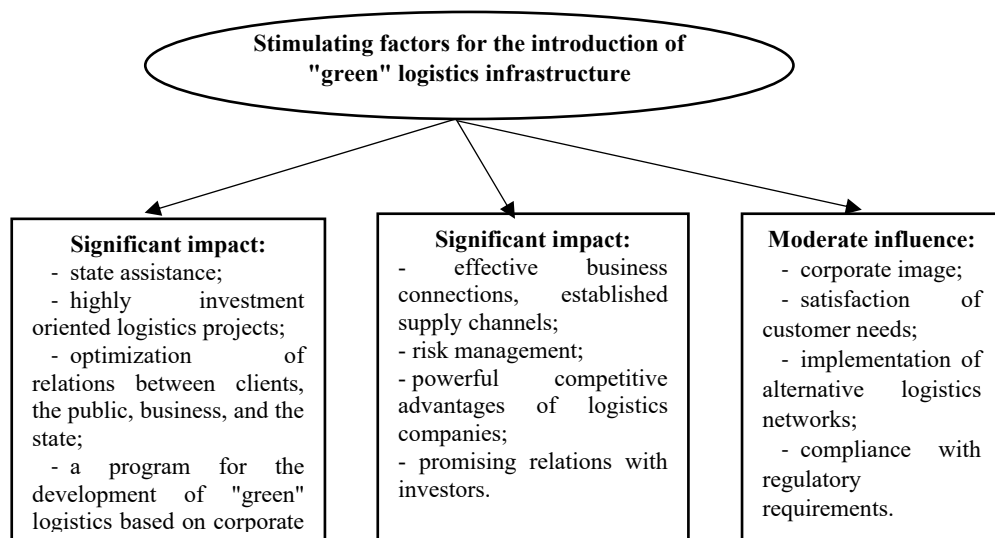


Fig. 4. Stimulating factors for "green" logistics infrastructure according to the degree of their influence.

As a result of the implementation of "green" innovations, the logistics infrastructure will receive certain advantages, which are presented in Figure 5.

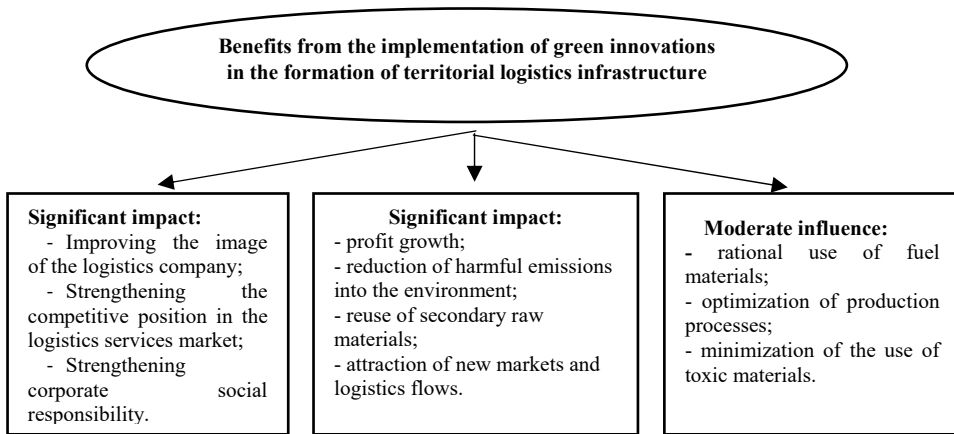


Fig. 5. Advantages by the degree of influence from the introduction of "green" innovations in the formation of territorial logistics infrastructure.

In their studies, Margit and Bilonizhka [8] investigated the activities of companies in the field of "green" logistics [8]. These authors considered the activities of world-class multinational companies and their green innovation projects in the field of logistics (Table 3).

Table 3. Transnational companies and their green innovative projects in the field of logistics [8].

Company	Innovative projects of green innovations in the formation of territorial logistics infrastructure
Green Cargo	Innovations in locomotives with low electricity consumption
Xerox	Reprocessing of spent cartridges
Toyota	Using wind turbines that produce 3MW of electricity
Johnson& Johnson	The "Healthy Future" program - increasing waste productivity, reducing CO ₂ emissions
K Line	A Japanese shipping company has installed a system that optimizes engine performance by monitoring weather and hydrographic conditions

Interesting in the application of green innovations in the formation of territorial logistics infrastructure is the experience of Denmark, where local authorities and private business conduct an active incentive policy to reduce energy consumption, reduce emissions and increase eco-production. Austria's experience shows that the joint actions of the authorities and business contributed to the development of the Climate Protection Program, which aims to create an integrated electronic system of transport, logistics and service, which allows businesses to use resources repeatedly.

In the UK, which is a leader in digitalization, the "green quarter" experiment has been implemented, where restricted access has been introduced in the city center, which has significantly reduced emissions into the atmosphere due to increased traffic speeds, a charging system has been implemented that uses license plate recognition software and vehicle tracking for the police. Also, since 2015, a road strip has been developed in Great Britain that charges hybrid and electric cars. In Spain, local authorities in the management of the city use garbage containers that control the volume of waste, optimize routes and implement sensors that determine the harmfulness and danger of waste [31].

The experience of Sweden, which is a leader in green innovation, is very interesting. It is the world leader in the consumption of renewable sources of energy and fuel. The country's government encourages the introduction of green innovations in all areas of the economy, where the main requirements are energy efficiency and renewable energy resources. Sweden receives electricity and heat energy from the disposal of household waste, households receive tax breaks for switching to renewable energy sources, tax cuts for car owners who use environmentally friendly fuel and offer them free spaces in city parking lots. Ukraine signed the Association with the EU regarding the transition to the green European model of development. The green growth of the economy is innovative in nature and will contribute to the modernization of the economy through the implementation of the following measures: minimal use of resource-intensive industries and the transition to high-tech ones; strengthening the innovative activity of enterprises through the expanded use of resource- and energy-efficient technologies; strengthening business competitiveness through rational use of energy and material resources, gradual transition to zero-waste production.

The potential of the Ukrainian economy in terms of green innovations is contained in energy efficiency, expanding the use of renewable energy sources, organic agriculture, waste sorting and minimization, as well as the implementation of other environmental innovations. Ukraine has an extensive railway network and inland waterways, which allows minimizing the harmful effects of transport.

The use of green innovations in the formation of territorial logistics infrastructure is also possible within medium-sized enterprises. Yes, green innovations in logistics are possible due to: reusable containers and packages; thermal insulation of warehouse and logistics premises, thereby reducing electricity and heating costs; reduction of paper document circulation, thereby introducing the latest technologies for maintaining financial documentation, improving business digitization and reducing costs for paper, cartridges, paint, and electricity; reduction of CO₂ emissions due to optimization of routes and loads, reduction of idle time, minimization of fuel consumption.

In Ukraine, even in the conditions of war, the usual forms of doing business are gradually changing. There is an increase in green projects. Successful companies strive not only to increase profits, but also to achieve a positive social and environmental effect. Successful business around the world is gradually abandoning exhaustible fossil fuels as a type of fuel for logistics networks and production, the positions of sustainable energy, hydrogen technologies and clean fuels are gradually being strengthened. In recent years, the ecological efficiency index has been calculated. This is a global study of how states fight environmental pollution and contribute to the development of the ecosystem through measures to preserve natural resources and implement an active environmental policy. The final assessment of the country and its place in the rating is the total value of 32 parameters.

Table 4. Index of the level of development of the green economy [6, 9].

	Index of the level of development of the green economy in 2014	Index of the level of development of the green economy in 2022
Denmark	76,92	77,90
The United Kingdom	77,35	77,70
Finland	75,72	76,50
Malta	76,42	75,20
Sweden	78,09	72,70
Luxembourg	83,29	72,30
Slovenia	76,43	67,30
Austria	78,32	66,50
Switzerland	78,09	65,90
Iceland	76,50	62,80

In 2014, Ukraine took 9th place in this ranking, and in 2022 it took 52nd place [14, 15]. Despite the significant advantages of green innovations, future investors face a number of obstacles, among which the following should be highlighted: obstacles in terms of environmental regulation (lack of motivation among private companies and households to rationally use scarce resources); obstacles in terms of scientific research developments and implementations (insufficient financing of private developments, lack of complete information regarding further implementations of developments); market-type obstacles (the high cost of developments and their implementation costs lead to the rejection of green innovations, the uncertainty and duration of the deployment of alternative green technologies leads to a decrease in investor interest).

It is possible to conduct a SWOT analysis of the adoption of "green" innovations in the creation of territorial logistics infrastructure based on the significant scientific discoveries of prominent domestic and foreign researchers and fusing them with their own scientific vision.

Table 5. SWOT analysis of the implementation of green innovations in the formation of logistics infrastructure.

<p style="text-align: center;">Strengths</p> <p>Overcoming hunger, development of agriculture Sustainable development of cities, communities, infrastructure Clean energy, clean water, clean power available Reduction of energy intensity of production Reducing the amount of production waste through the implementation of innovative measures for their processing</p>	<p style="text-align: center;">Weak sides</p> <p>Rapid growth of innovative capital Mistrust of innovative technologies on the part of business owners Rejection of the use of green resources due to their relative high cost Low consumer awareness of green innovations and their benefits from implementation</p>
<p style="text-align: center;">Opportunities</p> <p>Reduction of emissions of greenhouse gases, CO₂, the negative impact of pollutants Ensuring the preservation of infrastructural ecosystems: land, water, mountain General economic growth Decent remuneration of labour Strengthening the energy balance of the country Development of innovative infrastructure and the basis of green technologies Sustainable GDP growth</p>	<p style="text-align: center;">Threats</p> <p>Refusal to use green innovations by business owners due to conservative views, indifference to the ecosystem, refusal of responsible consumption Abandonment and consumer indifference due to ignorance Insignificant state support for innovative green projects, undeveloped legislation on green innovations in the formation of territorial logistics infrastructure</p>

As experience has shown, green innovations are most fully implemented in countries with a stable innovation and investment climate, and through the implementation of the following measures:

- development of mechanisms for painless exit of the investor from the green project in case of failure;
- encouraging competitive markets open to the introduction of green innovations;
- balanced macroeconomic policy.

In addition to market conditions, the government should be interested in the implementation of green innovations, and apply targeted mechanisms that stimulate the increase in demand and supply for green innovations, stimulate entrepreneurial activity to develop green innovation projects,

5 Conclusions

The growth of the development of the green economy is possible through the provision of such tools as tax incentives, incentives for resource conservation, energy conservation, the introduction of stricter environmental standards and technical conditions, a system of indicators for evaluating the effectiveness and efficiency of environmental implementations and technologies.

As a result of the study, the financial and economic effect of the development of the territorial logistics infrastructure was revealed, which is achieved through the use of combined transportation, cost-effective routes, optimal use of warehouse areas, the use of adequate pricing for logistics services, which will entail higher added value and increased profitability. A positive financial and economic effect is ensured by creating a favorable business environment, reducing tax pressure, and effective fiscal and budgetary policy. The application of green innovations in the formation of logistics infrastructure requires the achievement of an ecological effect through the use of renewable energy sources, the wider use of energy-saving technologies, the use of "green" packaging (innovative packaging technologies, waste sorting), the minimization of emissions of harmful substances into the atmosphere and the spread of the use of environmentally friendly vehicles and social effect through increasing the social responsibility of business representatives, improving "green" management (environmental quality management, training employees in environmental management knowledge, promoting initiatives on environmental measures, adjusting environmental management strategies).

Problematic aspects of the implementation of green innovations in the formation of logistics infrastructure are identified, which consist in the stages of supply, information technology operations, sales, production service and transportation. The analysis carried out as a result of the research made it possible to conduct a SWOT analysis of the implementation of green innovations in the formation of territorial logistics infrastructure and to identify their strengths and weaknesses, opportunities and threats. Green innovation research is a never-ending process with further refinements and improvements

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